[redacted]

RCT Bone Densitometry Technologist Portfolio

[redacted]

Bone Density Technician

[redacted]

JUNE 2022

Table of Contents

Section **Page No.**

!"#Introduction

I was employed as a band 5 DEXA/DXA (dual energy X-ray absorptiometry) Bone Density Technician within the [redacted] at [redacted] in October 2017. My past scientific academic achievements include a BSc (Hons) in Forensic Biosciences followed by an

MSc (Res) in Translational Oncology. During my degree I took on a placement year within the Bone Oncology department as a Research Laboratory Technician which began my keen interest in the study of Bone.

This Portfolio will guide the reader through my daily activities as a DEXA Bone Density Technician here at the [redacted] including the work I perform and my competencies which should in turn give sufficient evidence that I meet the RCT equivalence criteria for the Register of Bone Densitometry Technologists. Along with this portfolio I will also submit the application form, the job description for my current role, an organizational chart for the department to which I work, my up-to-date Curriculum Vitae (CV) and finally any other documentation to which I feel is deemed relevant for submission.

2. Osteoporosis

Osteoporosis is often termed a "silent" disease as patients are usually asymptomatic until they experience a fracture. It is characterised by low bone mass (figure1) contributing to a higher risk of fracture, specifically in the spine, hip and wrist. As the disease increases with age it is one of the primary causes of both illness and death in the elderly, with 1 in 3 women and 1 in 5 men sustaining a hip fracture when surviving up to 80 years of age[1]. In 2018 the UK alone had an estimated 3 million people diagnosed with Osteoporosis to which 500,000 were admitted to hospital with fragility fractures. These estimated figures result in an annual cost to the NHS of around £4.4 billion[2]. The number of osteoporotic fragility fractures are expected to double over the next few decades which in turn could lead to economic burden on our healthcare services[1]. The WHO diagnostic criteria for Osteoporosis helps distinguish between a diagnosis and is explained in more detail under the technical interpretation of Bone Densitometry section of this portfolio. The fixed risk factors that contribute to Osteoporosis include; age, height loss, female gender, ethnicity, family history, previous fractures,

menopause, amenorrhea and oestrogen deficiencies. Modifiable risks include; alcohol, smoking, medications, low body mass index, eating disorders, infrequent exercise, Vitamin D deficiency, poor nutrition and frequent falls. Osteoporosis can be prevented by early identification and intervention[1].

2.1 Clinical Presentation.

As previously mentioned, Osteoporosis is asymptomatic disease and therefore the patient does not know they are at risk until they obtain a fracture. These fractures usually occur due to a minimal impact injury; for example, a fall from standing height and are called fragility fractures. Risk factors for fracture include ageing, falling to the side, failing to break your fall, low BMD and poor bone quality. Risk factors for falling include vision loss, muscle weakness, balance, and certain medications[3].

Only 25% of vertebral fractures have acute clinical presentation with only 1 in 4 presenting clinically with sudden onset of severe back pain. Patients may not know they have a vertebral fracture as the pain may not be localised to the site of the fracture. For example, a patient may feel a sharp pain in their rib area, characterising a rib fracture but have a thoracic vertebral fracture[3]. Pain can last between 6-8 weeks. Chronic pain is more likely due to multiple fractures within the spine.

The clinical impact on the patient can include; pain, rib impaction, deformity of the spine resulting in height loss and kyphosis. Patients may also have respiratory and abdominal issues and may suffer a loss of confidence in their ability to move and walk around in fear that they may fall again[5].

The Mortality rate in first year post hip fracture is as follows; approximately 20% of people will be die within 1 year, 30% will have permanent disability, 40% will no longer be able to walk independently and 80% will lose the ability to carry out at least one daily independent activity. This

causes a huge consequence for not only the individual but also their family, the health and social care system and the economy[1].

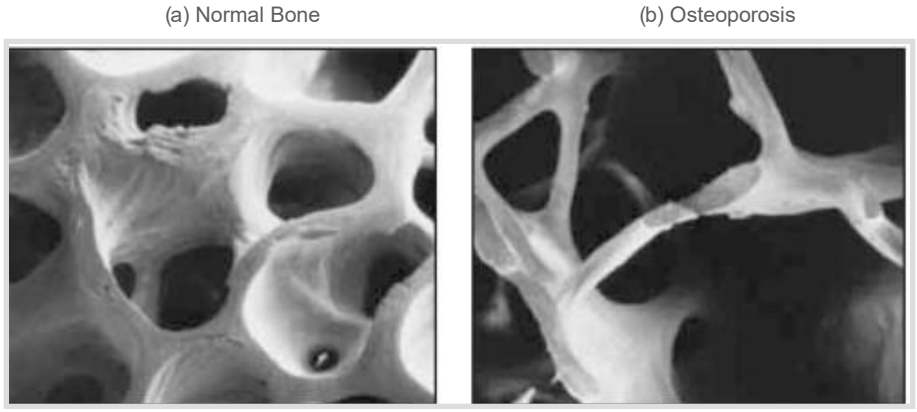

Figure 1: Scanning electron micrographs from (a) normal bone and (b) osteoporotic bone. (a) Normal bone shows strong interconnected plates in comparison to (b) osteoporotic bone that shows poorly connected plates with loss of bone structure

2.2 Pathophysiology

In Osteoporosis the remodelling balance is disrupted causing excessive resorption, leading to weakened, brittle bones that are more prone to fracture. Pathophysiological models once emphasised that endocrine mechanisms contributed to postmenopausal osteoporosis, however more recently other mechanisms are thought to be a contributor. These mechanisms include, Impaired immune cell functions, Gut microbiome (GM), short chain fatty acids (SCFA), impaired intestinal barrier nutrient absorption and the accumulation of senescent cells, all leading to dysbalanced bone resorption versus bone formation which in turn contributes to Osteoporosis[4].

There are low & high trauma fractures in people with osteoporosis. A fall from standing height or less fulfils the criteria for a fragility/low trauma fracture. It is the bone strength that determines whether a person will sustain a fracture. BMD combines the amount of bone built while developing and growing towards peak bone mass and the amount of bone lost since. In relation to bone size bigger/thicker

bones are stronger and finally bone turnover, microarchitecture (structure, connection and regularity of trabecular) and mineralization help distinguish the quality of the bone[5].

2.3 Bone Biology & The Remodelling Cycle

Bone is a living tissue that remodels constantly and is metabolically active, therefore constantly changing. Bone provides structural support for the body, protects organs and provides an environment for bone marrow whilst also acting as a storage area for calcium and other minerals. Once peak bone mass has been reached in adulthood, bone remodels constantly and is metabolically active[3].

There are two types of Bone;

- Cortical Bone – Represents 80% of the skeleton, has a slow turnover and therefore is difficult to regulate with anti-fracture drugs. Most abundant at the distal radius.
- Trabecular Bone – Represents 20% of the skeleton, has a rapid turnover of minerals including calcium and phosphate and is more active and therefore easier to regulate with anti-fracture drugs. Most abundant in the vertebrae.

The Skeleton grows really rapidly during childhood, increasing during puberty until peak bone mass is reached at around the age of 30. Once peak bone mass has been reached in adulthood there is a trivial level of bone loss however, this greatly increases after the age of around 50. Men have a BMD decrease of around 1% per year. Women however, have a sudden decrease in BMD for

around the first 5 years post menopause, this then stabilises to a loss of around 1% per year[3].

The cell types responsible for bone turnover which is the renewal of bone, include Osteoclasts, Osteoblasts and Osteocytes. Osteoclasts resorb bone whilst Osteoblasts rebuild bone following resorption. Osteocytes initiate or control the cycle to ensure we maintain healthy bones; they do this by sensing the undergoing daily stresses the bone might be under. This removal and rebuilding of the bone cycle ensures we end up with the same amount of bone that we started with and thus in normal

healthy young adults, there would be no net loss of bone. As we age bone is removed more and replaced less and is one of the main reasons for Osteoporosis in menopausal women[3].

2.4 Causes and Risk Factors

Inflammatory Diseases: Systemic inflammation increases the risk of osteoporosis and fracture. Inflammatory diseases include; Rheumatoid arthritis, seronegative arthritis, connective tissue diseases and inflammatory bowel disease. Endocrine Disease: Thyroid hormone and parathyroid hormone (PTH) increase bone turnover. Thyroid hormones increase metabolic rate of the entire body including the bone. PTH drives osteoclast function to resorb bone and increase serum calcium. Endocrine diseases include Hyperthyroidism and primary hyperparathyroidism. Cortisol increases bone resorption by osteoclasts and induces osteoblast apoptosis, decreasing bone formation. eg: Cushing's syndrome. Oestrogen and testosterone control bone turnover e.g: latrogenic/natural early menopause, male hypogonadism and anorexia. The decrease of sex steroid levels is a risk factor for osteoporosis therefore women who have early menopause naturally, surgically or due to cancer treatments are at risk along with men with testicular failure. Reduced skeletal loading for example; Immobility or low body weight increases resorption of bone. Medication such as glucocorticoids, Depo-provera (if started medication before peak bone mass BMD will decrease by approximately 5%), Aromatase inhibitors (treatment of breast cancer to reduce oestrogen levels), GnRH (breast cancer treatment) and endometriosis, Androgen deprivation treatment in men where by testosterone is blocked during treatment for prostate cancer and in turn decreases bone density). Other risk factors include previous fractures or family history of osteoporosis or fracture[6].

2.5 Fracture Risk Assessment Tools

The FRAX score was developed and launched by the [redacted] in 2008 to evaluate the fracture risk of patients. The calculator integrates demographic clinical risk factors with BMD at the femoral neck and makes a prediction of hip fracture or other osteoporotic fractures of the spine, shoulder or forearm to calculate the 10 year probability of fracture. Europe, North America, Asia and Australia population based cohorts were studied to develop the models. To calculate the probability of fracture the calculation tool uses the following risk factors; Age (between 40-90), sex, weight, height, previous fracture, parental fracture of the hip, smoking status, glucocorticoid use, history of rheumatoid arthritis, secondary osteoporosis, units of alcohol per day and femoral neck BMD[7].

2.6 Treatments

There are many treatments for osteoporosis including; Bisphosphonates, these are usually the first line treatment as they are cheap, effective and can aide effects. Oral forms of bisphosphonates include; Aledronate (daily or weekly), Risedronate (daily or weekly), Ibandronate (monthly). Some issues that arise from these oral forms are that many patients do not take them as prescribed and they also have side effects so many people cannot tolerate the oral form of the treatment. The IV treatments include Ibandronate (3 monthly) and Zoledronate (Yearly). Excellent alternative to the oral form for patients with side effects. Bisphosphonates inhibit an enzyme in the cholesterol synthesis pathway (Farnesyl Pyrophosphate Synthase). When an osteoclast is exposed to a bisphosphonate it internalises the bisphosphonate and therefore disables the osteoclast slowing down osteoclast activity allowing osteoblasts the chance to catch up and therefore maintain bone turnover. HRT (oestrogen) is a really effective way to minimise the risk of osteoporosis. Women who have early menopause replace the oestrogen that they should have had with HRT. If patients start treatment around the age 40 to around the age of 50 (around the time of natural menopause) it is seen to be a really promising form of

treatment. The benefits of HRT include reducing the the risk of fractures by about 50%, bone density may increase by up to 10%, it prevents hot flushes and other menopausal symptoms and can reduce the risk of colon cancer. Risks associated with taking HRT include; Breast cancer, stroke, vaginal bleeding, Venous thrombi-embolic disease and cardiovascular disease. Denosumab is a monoclonal antibody to RANKL (Receptor activator of nuclear factor kappa-B ligand) is another known treatment for Osteoporosis. Denosumab acts by intercepting the signal to the osteoclast to resorb bone and therefore by doing so switches off bone resorption. It is rapid acting and a very good fracture risk reduction treatment, however side effects can include skin irritations and low blood calcium levels. Teriparatide is a form of the PTH molecule and drives osteoblasts to build bone. The trabecular bone rebuild and reconnect and the cortex gets thicker. It is a very powerful treatment reducing the risk of fractures by more than 50% and increases bone density by up to 20%. The treatment is limited to 2 year course due to the risk of osteosarcoma. It is an excellent treatment but expensive and therefore is only really used in patients with severe osteoporosis. Some patients can report bone pain due to the increase in osteoblast activity, the treatment is otherwise safe and doesn't cause many other side-effects[8].

3. Daily Duties & Responsibilities

My daily duties include performing daily DXA scans and vertebral fracture risk assessments (VFA), using one of the three Hologic Dual energy X-ray absorptiometry (DXA) scanners, whilst adhering to both Ionising Radiation Regulations 2017 (IRR2017) and the Ionising Radiation (Medical Exposure) Regulations 2017 (IR(ME)R). I am responsible for analysing DXA and VFA scans and follow FRAS protocols to assess whether patients need further clinical investigations such as an XRay or blood tests.

I am competent in all technical aspects of bone densitometry and display a high level of accuracy when scanning and analysing images. I also feel confident in my ability to read VFA and X-ray

imaging to identify fracture deformities and normal variants. I am familiar with all clinical pathways and ensure that I am meticulous when following standard operating procedures (SOP), IRR2017 and IR(ME)R. I apply all my knowledge accurately to make the right clinical decisions, quickly and effectively. Furthermore, I help to manage the daily, weekly and monthly quality control (QC) of all scanners within the department, maintaining equipment and checking for any physical damage whilst ensuring to report any issues to the chief technician. Additionally, If required, I will report the issues to Vertec Scientific and provide information to them on any mechanical failures whilst arranging an appropriate time for them to attend for repair. Vertec Scientific supply and support a wide range of health technology products including the Hologic DXA scanner used within our department. Within the department we work as a multidisciplinary team, from administration staff to clinical leads, which has given me the ability to work with a wide variety of other trained professionals to ensure the smooth running of the department.

My other duties include locating and restoring scans onto the relevant scanner in advance of appointments which enables checks to be made to ensure the patient is scanned on the correct room, within the correct time scale and therefore avoids delays on the day of the patient's appointment and patient duplication. I always ensure to prioritise my daily duties appropriately, making sure to send scans at the start of the day to the Picture Archiving and Communication System (PACS) which securely stores the patients scans for reporting. I allow myself the time prior to my first patient arriving to conduct general housekeeping duties including infection control measures and the stocking up of equipment which upholds an organised way of working.

Good Scientific Practice (GSP) is a set of professional standards that all healthcare workers should follow within their daily role. I always strive to meet these standards in my position which is further demonstrated below. As part of my role, I work and interact with patients daily. I always ensure to

promote my PROUD (Patient First, Respect, Ownership, Unity and Deliver) values by always making sure the patients' needs are my priority, ensuring they are seen ahead of their appointment times where possible. One of my personal core values is to always have selfless commitment by putting the needs of the others before my own. I always ensure that I listen to my patients and remain approachable and open to their concerns. I note any relevant patient information clearly so that any issues can be raised and dealt with at the earliest opportunity. This helps to protect the patient where possible and ensure their care and safety is always taken seriously. On many occasions I have received positive feedback from patients who often describe me as a caring, compassionate and happy individual with great knowledge of my role. Unexpectedly, I have also received thank you cards from patients which alongside management feedback greatly increases the confidence I have in successfully demonstrating all my PROUD values and means that patients, their careers and visitors have an exceptional experience during their visit to the department.

Respecting and valuing patients, staff and visitors by always being professional is an important part of my role. I ensure to listen and communicate effectively whilst understanding people’s differences. I am also an honest and open individual and always maintain both patient and staff confidentiality. Due to the backlog of patients over the past year or so and the increasing issues this is causing for patient care, I have taken it upon myself, in my own personal time, to compile ideas as solutions to the issues and have actively proposed them to the Chief Technician, to support them in trying to figure out alternative ways to increase patient activity within the department.

Having a calm, friendly and hardworking demeanour allows me to always offer an extra hand and encourage and support my colleagues by unifying the team through highly pressured times. It also means a great deal to me when I receive positive comments from my colleagues, who have commented on my positive nature and how I improve the moral of the team.

I am highly motivated and always try to approach everything I do positively. I am always looking to identify issues within the immediate working environment and offer solutions to improve working practices. I also try to recognise problems within the team and try to use common strategies to strengthen in-team relationships. I am a very focused individual and therefore I am more than capable of working in isolation which I demonstrate daily in my current role when scanning patients independently, however I always seek further guidance from senior staff members if I have any doubts or need further clarification on complicated matters. On top of this I am an organised individual and show initiative to ensure that all jobs are completed in a timely and accurate manner, enabling work to be carried out safely and without delay. I respond well to feedback from my hierarchy and will always try to improve on my performance where possible.

As part of my role it is important to reflect on my scanning practice and I ensure to adapt my practices to accommodate the needs of each individual patient (service user). An example of when I have had to do this in my role is with patients who are uncomfortable when lying flat on the scanning table and who may require a slight change in positioning during the scan. This may be by adding an extra pillow under their head, especially if the patient is very kyphotic. If the patient has difficulty lifting their legs as high as required, I have learned to position the box on its lower side for the lumber spine and VFA scans. There may be times when the patient has had surgery or suffered a stroke and therefore cannot lift their arms or one arm above their head for the VFA scans and thus to keep the patient as comfortable as possible, I will not ask the patient to lift their arms for these scans. There may be times when patients are nervous for their scans especially new patients who do not know what to expect during their scan, some patients may feel more comfortable closing their eyes whilst the scanner bed is moved into position or some prefer verbal step by step explanation of the scan whilst it is undertaken. I will always comfort my patients if required, by offering them a glass of water before commencement of the scan and will advise them to take deep breaths during the scan. I will always

ensure the patient knows that I can stop the scan at anytime if they are in any discomfort due to positioning or to anxious to continue. I add any changes in my scanning practice to the comments section of the patients paperwork so that the reporting clinician knows of any difficulties in patient positioning or other problems that may effect the scan, it also is a great way to reflect on what I could have done differently and what I can change if they arise in future.

Leadership skills are an important trait and I therefore take every opportunity I can to put myself in a position to lead and develop others. I have previously taken the opportunity to provide DEXA training to the new scanning staff. In doing so I have been able to share my own skills and knowledge of the role with them. On this note seeing junior staff develop and scan independently using my scan technique has ultimately given me a great deal of confidence and satisfaction in my leading skillS.

Being a proactive individual who strives to deliver a professional, efficient and effective service means I always put the organisations needs before my own, I seek to help management staff by booking my annual leave well in advance to ensure the appointment booking deadline is met and by always being flexible with my working hours, amending my shifts to avoid patient cancellations. Moreover, I am flexible with my working days so that other team members can get the annual leave they require during staff shortages which has not only been extremely helpful to the band 5 technical team but also to higher management who have appreciated my efforts to accommodate.

I am a proficient user of the Internet and many computer packages including Microsoft Word, Excel, Power Point and Outlook. I have excellent written and oral communication skills and have had the opportunity to undertake assessed presentations as part of my MSc (Res) in Translational Oncology. I always ensure that I read and update my knowledge on the latest technical information that is

published so that I can remain fully competent in my role and make it a priority to complete all mandatory training on time which ensures I am up to date and can provide the best care possible.

3.1 Appointment scheduling

Within the department on busy occasions I have been asked to assist with appointment scheduling which consists of checking patient referrals to see if the patient has had a scan with us before and then ensuring the patients previous scans are located on the corresponding scanner. I must also check the patients information for any known disabilities or language barrier on the referral or via CRIS which may affect the scan time due to the need for extra support to be in place before the scan date. The challenges faced with booking appointments is that there are many occasions during the appointment scheduling whereby the information is not always available and this ultimately leaves scan technicians unaware of any patient disability, duplication or the need for an interpreter until the time of the appointment which can cause patient delays. It is vital to check whether the patient has been before and what scanner so that the patients scan can be analysed against their previous scan which avoids patent duplication and incorrect further clinical investigations. It is also important to identify whether the patient has any known disabilities either on the referral or via CRIS so that the appropriate booking slot can be made, for example, if the patient requires the use of a hoist they will require a double booked appointment scan slot so that we can support the patient as much as possible within a timely manner, if there is not a double booking in place this delays appointment times by taking up another patients slot. There are also patients who may require an interpreter to assist them through their appointment which may lead to delays if there is no interpreter in place and we have to call the translation service to confirm personal information or complete questionnaires relevant to the scan. It is not always possible to know if the patient has had a previous scan with us, especially if there has

been a long time gap between scans, I always ask the patient whether they have had a scan within the department previously, just to avoid any duplication errors that could lead to incorrect patient care. If they think they have but the information is not reflecting as such on our systems, they may have been triaged incorrectly as a new patient. This causes patient delays whilst all scanners are then checked to locate the patient and if the patient is then located on another scanner their appointment time will be delayed until the correct scanner becomes free to use.

3.2 Record keeping

The department keeps daily record logs for cleaning down the equipment. After each scan the scanning bed and equipment, door handles and computer desk and keyboard are thoroughly cleaned. Before the scanning room is closed down for the evening the room is again thoroughly cleaned down and then the daily cleaning log is signed by the appropriate technician (Appendix 1). Each scan room contains a daily check list of all duties for the week ahead which is ticked off by the technician once complete. The completed patient questionnaires are attached to the FRAS documentation and sent through to the consultant for reporting (Appendix 2).

4. Safe Working Practice

Safe working practice is an extremely important part of my day to day role day to ensure not only the safety of the patient but also the safety of staff. All mandatory training should be completed either online or in practical sessions and includes moving and handling, infection prevention and control, resuscitation (adult basic life support), fire safety training, safeguarding and data security , Confirmation of certification can be found within Appendix 3 of this portfolio.

The infection control measures I adhere to when scanning patients include cleaning the scanner and all equipment within the scan room prior to the arrival of each patient using a solution called Tristel,

which is made up on the morning of the scanning day by our Healthcare Assistants (HCA). Wiping down the work desk is also important, especially at shared work stations. The correct personal protective equipment (PPE) should be worn prior to the scan if required and may include a surgical mask, gloves, apron and visor. Hands should be washed before and after each patient contact and alcohol gel wash is also provided.

To ensure the safety of patients and staff appropriate moving & handling group training is provided each year. This training provides practical exercises to train staff in the use of moving and handling equipment. Within my day to day role patients may require assistance on and off of the scanner and so within our department we have the use of ceiling hoists, a SARA steady, walking frames and slide sheets to assist in the safe movement of stretcher or bed bound patients onto the scanning bed. It is vital to assess the safety of each patients needs and also to ask each patient if they require assistance when getting onto the scan bed. Adult basic life support is provided online which is undergone yearly and ensures staff know the correct procedure to undertake cardiopulmonary resuscitation (CPR) and defibrillator use until the [redacted] crash team arrive in the department.

As a DXA scanning technician I am required to lone work with my patients during scanning activity. The risks associated with lone working include being more vulnerable to the act of violence by patients who attend the appointment. Some patients may have violent tendencies linked to mental health issues or alcohol abuse and if they are not flagged during appointment booking times than we as technicians may not know the risks associated with the patient. I will always ensure to check CRIS for any alerts the patient might have and read over questionnaires to highlight unknown mental health disabilities before bringing the patient into the scanning room for their appointment as it is easier to assess the risks involved when working alone with them. At times it is beneficial to ask for extra support during the scan by other technicians. Other risks in terms of lone working is injury to yourself or patient injury by falls. Within each scan room an emergency buzzer is located by the door and can

be activated in any emergency to alert other staff within the department that you require immediate emergency assistance.

5. Radiation and Regulations

5.1 Biological Effects of radiation and radiation dose

Ionising radiation including X-ray used in DXA, form an important role in modern medicine from diagnosis to therapy. A small amount of radiation is beneficial however too much can lead to injury or even death and so it is important to measure the amount or dose administered.

Radiation dose quantities include;

- Absorbed dose (symbol D) the amount of energy per unit mass that is absorbed by a material when exposed to an X-ray beam. Unit = Joule/kg (Gray/ Gy).
- To form an image an X-Ray beam; o Interacts with tissue as it passes through tissue o Transfers energy to the tissue

It is the energy transferred that can give rise to potential harm due to its ionisation effects.

Different types of radiation show different types of effectiveness at producing damage in tissue and different tissues have different susceptibilities to damage. Effective Dose (symbol E) is a quantity that can represent the risk of being exposed to X-rays and ionising radiations. It is based on absorbed dose but modified by weighting factors to take into account of differing radiation effectiveness and tissue sensitivities. Effective dose also has joules/kg and is also referred to as the sievert Sv9.

Radiation damage is caused by ionisation whereby ionised molecules become unstable and in returning to a stable state may alter their configuration. If this happens to a biological molecule, they may no longer perform their cellular function correctly which in term leads to damage[9].

The resulting outcome for radiation damage include;

- Normal repair of damage – The cell identifies the damage and returns the cell back to its normal state ie: Normal function and normal cellular reproduction.
- Cell dies due to complete damage
- Daughter cells cannot function and die
- No repair or non-identical repair before reproduction resulting in a mutated cell line

5.2 Clinical effects of radiation

The clinical effects of radiation include;

1. Tissue reaction

- Deterministic effects: Range of acute, whereby initiate immediately from a few days to a few months and chronic effects that may occur many years later.

2. Development of cancer or heritable effects

- Stochastic effects: Random chance and develop from about 5 years onwards, indistinguishable from other cancer types and heritable effects

In the United Kingdom the natural background radiation dose is about 2.2 mSv (millisievert dose) per year and the average dose of radiation in the UK population is 2.6 mSv with 2.2mSv (85%) of this being due to natural background radiation. Natural background radiation includes, cosmic rays, radioactivity in the atmosphere or our bodies and radioactivity in building materials. The other 12% is from medical exposure and 3% from fallout [9].

Typical effective doses started with the lowest dose and increases to the highest dose;

- Bone Density Scan (DXA) (patient dose 0.001-0.01 mSv)
- Flight to Spain (0.01 mSv)
- Chest X-ray patient (0.02 mSv)
- 1 week holiday in Cornwall (0.1mSv)
- Annual UK average natural background (2.2 mSv)
- CT abdomen (10 mSv)

Bone densitometry uses ionising radiation and thus patients receive X-ray exposure, however as a low dose of radiation is used to make a measurement, the risks associated with the exposure are very low[9].

5.3 Radiation Protection: Legislation & Protection

As a DXA technician I must comply with Ionising Radiations Regulations 2017 (IRR17). IRR17 results from European commissions (EC), Euratom Directives and govern all uses of ionising radiation, from medical diagnosis to operation of nuclear power stations. This concerns the safety of staff working with radiation and the public in result of such work being performed.

There are three main principle of radiation protection

1. Justification – must produce a positive net benefit. Exposure to ionising radiation must be justifiable
2. Optimisation – Must keep doses as low as reasonable possible (ALARP)
3. Limitation – The radiation doses received by both staff and public must be as low as practically possible

Setting up a new DXA service that has with no previous diagnostic radiology use, begins by notifying the Health and Safety Executive (HSE). HSE must be notified at least 28 days before work begins. A

risk assessment should have been carried out and will be part of the notification to HSE and will enable to employer to produce guidelines to the action necessary to reduce exposure to ionising radiation to ALARP and to ensure to not exceed the radiation dose to any staff or public persons[9].

There are many hazards of operating X-Ray equipment and they include;

- Large dose of radiation is possible if exposed to the X-Ray beam
- Receiving a small radiation dose from X-rays scattered by the patient's body and anyone may receive this dose

5.4 Dose Limits in accordance with IRR17

Dose limits protect both workers and members of the public from effects of ionising radiation of the eyes, skin and extremities (Table 1). It is an offence under IRR17 to exceed a dose limit and is in place to avoid the risk of serious side effects of ionising radiation as mentioned under the clinical effects section above [10].

Limit	Employee >18 years	Trainee 16-18 years	Other persons (not including comforters or carers)
EffecAve Dose	20	6	1
Equivalent Dose to lens of eye	20	15	15
Skin	500	150	50
ExtremiAes	500	150	50

Table 1: Dose Limits under 1RR17 for all public to protect them from the effects of ionising radiation.

IRR17 appoint Radiation protection advisors (RPA) and radiation protection supervisors (RPS) who investigate and notify any incidents to HSE in relation to equipment malfunction. They also monitor radiation dose to show compliance and provide local rules[10].

5.5 IRMER 2017

Ionising Radiations (Medical Exposure) Regulations 2017 (IR(ME)R 2017) aim to make sure that ionising radiation is used safely and that the risk to patients from the possible effects of radiation is minimised[10].

The regulations set out the responsibilities of duty holders, the Employer, the Referrer, the IR(ME)R Practitioner and the Operator, for radiation protection and there are basic safety standards that these duty holders must meet.

These responsibilities include:

1. Minimising unintended, excessive or incorrect medical exposures to radiation
2. Justifying each exposure to ensure that the benefits outweigh the risks
3. Optimising diagnostic doses to keep them as low as reasonably practicable. (ALARP)

Under IR(ME)R the duties of staff requesting, authorising and performing radiological tests are defined under three roles; *referrer*, *practitioner,* and *operator*. Compliance with IR(ME)R is a legal requirement, and it is the responsibility of the employer to ensure there is a set of written procedures in place to which the duty holders must adhere[10].

5.6 Radiology within Metabolic Bone

Staff who request, authorise, and perform radiological tests are defined under three roles; *referrer, practitioner,* and *operator.* How these standards apply to the various clinical pathways in the [redacted] are discussed below.

Within our department we provide standard referral forms for all GPs and secondary care referrers which state the acceptable referral criteria for requests for fracture risk assessment. For example, if

the referral is in the form of a clinical letter, it must be justified during the triaging stage in accordance with the set referral criteria.

Under specific written and approved protocols, non-medical referrers, such as nursers, are also authorised to request bone densitometry within our department. The referrers names can be located within each scan room and on the departmental management drive.

In certain circumstances various staff members are authorised to act as a referrer in accordance with written approved protocols. Once a scan technician has completed their radiation awareness training arranged by the MIMP (Medical Imaging & Medical Physics) Directorate they are then authorised to refer for spine X-rays. To do this the following criteria must be met;

1. The Vertebral Fracture Assessment (VFA) indicates the presence of a possible new vertebral fracture
2. The patient has had height loss of ≥ 6 cm since age 25 (young adulthood).
3. The patient has had height loss of ≥ 2 cm since their last DXA scan.
4. If there is an appearance on the DXA scan suggestive of a vertebral fracture.
5. If a medical practitioner has indicated that X-Rays are required, and the reasons have been clearly stated on the [redacted] assessment form.

When visual inspection of VFA imaging suspects fracture, it is important to consider the following before a request for a Spine X-Ray is initiated;

1. Both CRIS and PACS should be checked to ensure previous imaging including spine X-Rays, MRI or CT scans do not report the fracture
2. View all previous spine imaging if available to check for similarities in the appearance of the suspected fracture(s) as this may have been apparent and reported as another spinal deformity

3. If the CT scan image has not been reconstructed or if the Xray or MRI imaging was acquired many years ago before images were uploaded to PACS the operator must assume that the report on CRIS is correct. Therefore, if a fracture has not been reported, a request can be made for X-ray imaging to confirm or refute a suspected fracture on VFA. If the referrer has not reported a previous fracture in the referral and this has not been made apparent within the patient's questionnaire, it is acceptable to request spine X-ray imaging
4. If upon checking a fracture has been reported on previous imaging a request for X-ray is not required

The role of Referrer is acted upon by the [redacted] clinicians within our department. They refer patients for bone densitometry within the [redacted] and can do so in the following circumstances;

1. Clinic patients requiring follow-up bone densitometry for monitoring purposes
2. Clinic patients who are to be transferred onto the Primary hyperparathyroidism (PHPT) register
3. Time point monitoring for Direct Access Service patients
4. New patients requiring pre-clinic investigations based on written management advice from a Medical Practitioner

There must be a clinical signature/ Initials and dated authorisation on either;

- Clinical outcome forms
- Clinic letters
- [redacted] Assessment form for new Direct Access Patients or Pre-clinic investigations
- The ICE electronic system for g X-Ray requests or other imaging • An X-Ray request card if ICE is not available

5.7 IR(ME)R Practitioners

All exposure to radiation must be justified by a practitioner with adequate training who is a registered Healthcare professional. They are required to weigh up the potential detriment of exposure against the potential benefits for the patient and must access their clinical information provided by the referrer at the time of the request. Within our department the [redacted] clinicians act as practitioners and must sign or initial the document to indicate that radiation exposure is justified with the following;

- FRAS referrals
- New [redacted] referrals
- [redacted] follow up bone densitometry patients
- Direct Access referrals

5.8 Operators

Operators have a personal responsibility for the practical aspect of an exposure to ionising radiation. As a Bone Densitometry Scan Technician and under IR(ME)R it is my responsibility to meet all legislation and standards and thus I have the same duties and responsibilities as operators (Appendix 6). The operator scanning the patient has legal responsibility to check the identification and pregnancy status of their patients.

Firstly, I will check the patients date of birth and rule out pregnancy before the scan commences in accordance with departmental protocols. Both DOB and ruling out pregnancy physical protocols are in each scan room but are also found electronically on the departmental shared drive. Ruling out pregnancy using LMP is recorded on the back of the questionnaire, clinical outcome forms, Daycase pro-forma or communication forms. If a pregnancy test is carried out to rule out pregnancy the details of the test and the result must be recorded on the questionnaire or other clinical form and my initials are then recorded next to the result. Confirmation that ruling out of pregnancy and DOB checks have been completed for each patient is done via CRIS on the post-processing screen.

It is important that exceptional care is taken when identifying patients that may have learning difficulties, dementia, or those with a language barrier. A relative or caregiver who can confirm their identity is usually acceptable. For those patients who may require an interpreter, the language line interpreter service may be used to confirm identity of the patient, unless a friend or relative can confirm on their behalf. If the patient is an in-patient and is unable to confirm their identity, their identity wrist bracelet can be checked for confirmation.

It is also important to check that the patient is aware of the reason for the referral and to ask if they have been scanned previously as this helps to reduce the risk that the wrong patient has been referred by the GP or other referrer. It also prevents another scan being carried out especially if done recently at another hospital or even within our department on another scanner which may have been missed by the referrer.

Justification of the scan and timing of scan should also be checked prior to the scan for example, patients attending for Direct Access scans have scans at certain time intervals and therefore it is good to check the scan can go ahead if earlier than normal. I always check CRIS and PACS for recent spine imaging as the patient may also have had recent full spine X-ray or MRI that the practitioner was not aware of and therefore had justified a VFA scan in addition to the DXA. I will ensure to view the image on PACS to ensure it is complete. The DXA would still be performed however the VFA would not and would be rejected on CRIS and noted on the pro-forma or other documentation.

Other checks I perform include;

- Checking forms have been signed/initialled and dated accordingly by the practitioner
- Refreshing the work-list to select the appropriate patient and matching this with CRIS

- Ensuring that reception staff have booked the correct patient onto the correct room for the correct scans
- Making sure accession numbers match that of the patient before sending the images to PACS
- When supervising new trainees, I check all tasks the trainee performs in accordance with the protocols and sign and date all relevant documentation
- Ensuring that carers who need to support their patients during the scan understand the radiation exposure. I will also ask them to wear a lead apron. If they are female I am required to ask their DOB to ensure there is no risk of pregnancy before commencing the scan. I will sign and date the carers form which identifies the location the carer will stand in the scan room on commencement of the scan and ask the carer to sign the form to confirm they are happy to go ahead.

As a trained scanning technician, I can act as a practitioner to justify exposures if the patient requires additional imaging when attending for their bone densitometry assessment according to protocol and set criteria. These can include, VFA, Forearm or additional hip scans. Any additional imaging must be authorised in accordance with the set criteria, any scans that are not in accordance with this set of criteria are in breach of the regulations.

On occasion scanning errors may occur for example, clicking on the incorrect patient on the worklist and sending these images to PACS. This which can be found later and must be reported on DATIX. The referrer must be informed together with the patient if this could alter their clinical management.

If bone densitometry imaging is undertaken when it was not indicated this is classed as an unintended exposure under IR(ME)R 2017 and therefore becomes an incident. Although isolated incidents do not

lead to clinically significant over exposure, further similar incidents would be reportable to the CQC (Care Quality Commission) due to procedural failure.

To monitor staff radiation exposure to ionising radiation, I wear a whole body dosemeter that are provided by the RRPPS (Radiation Protection Services), an approved dosimetry service. Occupational exposure is governed by IRR99 to keep staff radiation exposure as low as reasonable practicable at all times. At the beginning of each new wear period, the RPS provides me with the dosemeter that is within a plastic pouch and should not be removed. The dosemeter is then worn on the front of my uniform, between the hip and the shoulder with my name and the date period facing forward. Any damage or loss of the dosemeter must be reported to the RPS as soon as possible. Records of all staff doses are kept by RRPPS and are routinely reviewed by the RPS and the Medical Physics Experts at [redacted] Staff are always informed if they receive a higher than expected radiation dose. The protocol for its use is located on the shared drive folder under radiation and includes local rules. It is vital for pregnant staff to inform the RPS of pregnancy at the earliest convenience although no specific changes are required for radiation purposes, it is important for appropriate moving and handling requirements and a decrease in the volume of clinical work that is undertaken during pregnancy.

Radiation risk assessments are carried out within each scan room and are there to evaluate hazards to minimise the risks of over exposure to all people and to keep this ALARP by adding control measures if required. The radiation risk assessments within metabolic bone cover the following to ensure this;

- A description of the area and equipment including;
- Room number eg: MB/D/12 Scan room 1, [redacted]
- Equipment ID. eg: Hologic Discovery A SN:12345
- Location of manufactures maintenance files eg: Lead Technicians Office, Room number

MB/D/1

- QA and log book files eg: Stored at work station. Room number MD/D/12
- Nature of Radiation eg; X-rays. Energy range: Dual energy X-ray absorptiometry system 70/140 kV
- Designation of controlled area eg: Yes. Whole room accept behind protective screen. Radiation warning light outside scan room door illuminate when the X-ray is turned on during set up
- Estimated radiation dose
- Workload and examinations undertaken eg: DXA of Lumber Spine, Proximal Femur and Distal Forearm in AP position. VFA of lumbar and thoracic spine in lateral and thoracic projection.
- Maintenance schedules - Who maintains and repairs the equipment, when and where stored eg; Vertec Scientific every 6 months. Stored electronically on shared drive.
- Departmental quality assurance schedules eg: Daily QC performed prior to clinical use
- Reg 83a - covering radiation warning signs, pregnancy warning signs, dose on the outside of the controlled area
- Description on work eg; diagnostic x-ray
- Description of personal (ACOP68) eg; Technologists and training provided, Nurses, Carers etc.
- Identification of person present during exposure if carer or other staff member and their location marked on room diagram
- Radiation monitoring of staff and estimated dose. eg: whole body less than minimum (<0.2mSv)
- Official Investigation for staff if staff accumulated more than 1.0mSv in the calendar year and steps taken

- Pregnant / Breast-feeding staff members (Reg 15(1) c; ACOP 273 and systems in place, who they report to and changes made if any
- Control measures eg - protective screens, emergency stops, lead aprons
- Local Rules
- Staff training required
- Foreseeable incidents and steps to prevent them
- Risk Level under regulation 13.1
- Contingency plans if staff or public receive a significant dose excess of 1mSv

Incident Reporting in Metabolic Bone

Following an incident within our department, immediate action must be taken by firstly informing a manager. Secondly a [redacted] DATIX web based incident report form available though the trust intranet must be completed as soon as possible with as much detail about the incident as possible and includes the following; • The type of incident

- Who was involved
- Name of who was affected
- The date and time of the incident
- Which site the incident occurred
- Ward/Department
- Directorate
- Speciality
- Description of incident
- Action Taken
- Any additional Information
- Who is reporting the incident

This is then followed up by an Incident review and further feedback by the manager. This helps all employees to learn from their mistakes and share that learning with others. As I have yet to submit an incident report I have provided an example of a submitted incident that has been reported within my department (appendix 7) and discussed this in more detail below.

A patient had visited the department for their IV Zoledronic acid treatment and as part of the direct access pathway they required a VFA scan only at their fourth infusion appointment. On attendance to the department the reception team had incorrectly inputted DXA scans of the hip and spine as well as the required VFA and thus the scanning technician performed a hip and spine BMD as well as the VFA in error without checking the request form. A clinician had picked up on this during the reporting process and had then submitted the incident to DATIX. The Chief Technician received and reviewed the DATIX and the incident was discussed with the scan technician involved. A completed local incident review was then sent to the Radiation Protection team in Medical Physics for review. Once reviewed they provided a report of the radiation dose and advised whether the incident was formally reportable or not and any action to be taken. On this occasion the incident did not need to be formally reported and the action they requested was for the scanning technician to be reminded of their responsibilities under IR(ME)R 2017. The scanning technician also had to write a reflective piece which was then attached to the local report. The DATIX was then updated with all the information reported and the incident was reviewed in our MDT meeting.

6. **Equipment Management**

The scanner including the bed, scanner accessories, handles, chairs, measuring equipment and any mobility equipment is wiped down with Tristel before and after each patient. At the end of each day I date and sign my own room for our cleaning records.

It is important during the referral process to check for any further patient information; such as infectious diseases that might effect the scanning day. Known infectious diseases such as MRSA require appropriate measures in place prior to the patients visit. The patient will require continuous barrier nursing from arrival to departure. Barrier nursing allows for staff to be protected by infection from the patient and also stops the patient from passing on the pathogen to non-infected hosts. When the patient arrives into the department for their scan they will need to be taken straight into the scan room so it is therefore vital that the correct personal protective equipment (PPE) is in place. The PPE used includes an apron, mask ,visor and gloves and must be won at all times during their appointment. After the patients appointment has finished hands must be washed throughly and relevant PPE disposed into the correct hazardous waste bin. The room will then require complete decontamination by the hospitals own infection control cleaning team. The patient will usually require the last scan slot available on a Friday. This ensures that the cleaning team can seal off the room for the weekend, helping to avoid the spread of infection.

6.1 Quality Control

For the DXA scanner to achieve meticulous results during scanning activity it is important to monitor the scanners performance each day. This ensures precise and accurate results for each patient and enables technicians to ensure the scanner is working to its full potential throughout its daily, weekly and monthly use (Appendix 4).

To confirm reliable measurements of Bone Mineral Density (BMD), Bone Mineral Content (BMC) and Area I perform a daily QC on each DEXA scanner at the start of each working day. For this QC a semi anthropomorphic spine phantom, provided by the manufacturer (figure 2), is scanned prior to clinical use and under standardised conditions. This ensures consistent results throughout scanning

activity. The result will then be documented by myself or another technical member of staff in our QC folder whereby other QC measurements, such as BMIL and ESR are recorded so that any monitored data can be checked for time induced gradual shifts which may indicate an issue with the scanner (such as the X-ray tube) and thus its accuracy. This ultimately can also invalidate the rate of change (ROC) of a patient's follow up appointment.

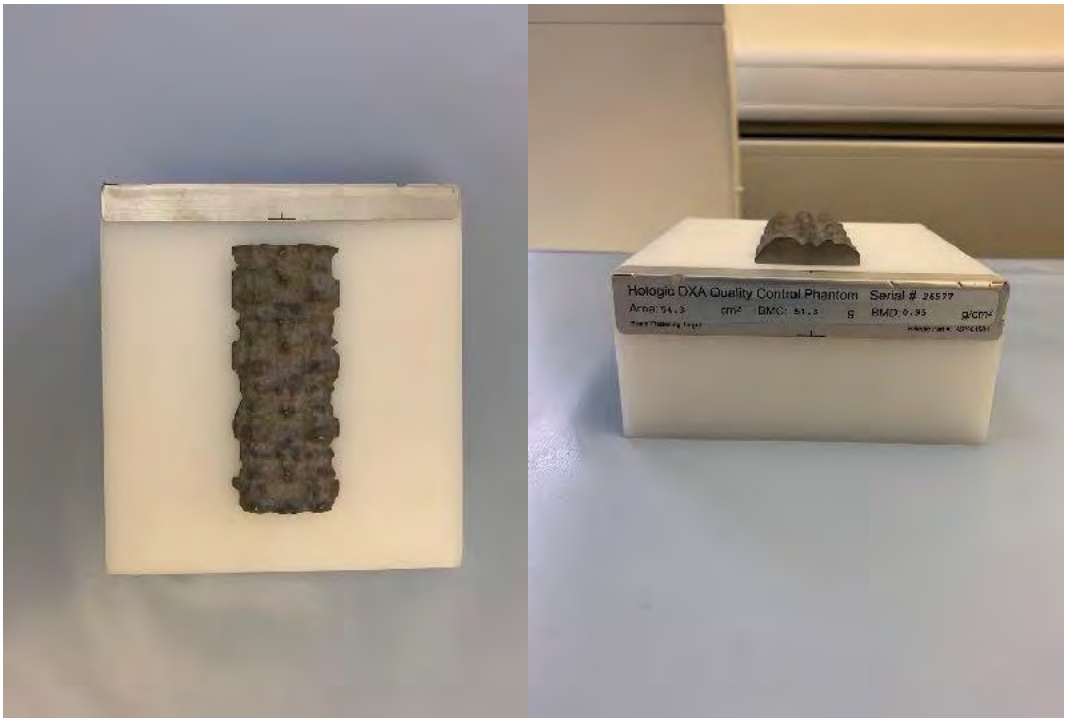

Figure 2 : The spine phantom used on our Hologic Dual energy x-ray absorptiometry (DXA) scanner. Four semi-anthropomorphic hydroxyapatite (HA) vertebrae (L1-L4) are embedded in a tissue equivalent material.

The dedicated spine phantom used on a Hologic Dual energy x-ray absorptiometry (DXA) scanner consist of four semi-anthropomorphic hydroxyapatite (HA) vertebrae (L1-L4) which are embedded in a tissue equivalent material. They are known to have a stable amount of bone mineral, approximately 1.05g/cm2.

For a daily QC scan to be performed on a Hologic DXA scanner, I firstly must ensure that the Carm is moved into a central position. This can be achieved by selecting the 'Daily QC' icon in the bottom

left hand corner of the main computer screen. The phantom is then positioned straight and central under the activated laser positioning light so that the laser cross hairs lie on the positioning mark located inferior to L4. Once I am confident that the laser runs centrally through all four vertebrae I can proceed to select the on screen continue button to allow the scan to start.

At the start, an automatic self-test is performed to allow verification that the X-Ray tube and detector are working correctly. During this test, photons are measured passing through air alone, this allows the alignment of the X-Ray source and detector to be checked. Once the initial test has passed, the spine phantom is then scanned in the array mode and the QDR system automatically analyses the image obtained.

The results for BMD (g/cm2), BMC (g) and Area (cm) are automatically plotted onto different daily QC graphs that are systematically generated; they each display a series of results from the phantom scans over a time period. The x-axis represents time (day, month and year) and the y-axis shows BMD (g/cm2), BMC (g) or Area (cm) depending on which graph is selected. The graphs are composed of three lines; the central solid line represents the reference mean value whilst the dashed lines set above and below are the upper and lower thresholds, they are calculated at ±1.5% of the mean, all set values are established when the machine is installed. Figure 3 shows an example of a daily phantom QC graph plotted for BMD between 17th June 2021 to 17th September 2021. The graph shows a reference mean of 0.945/cm2 with an upper limit set at 0.955g/cm2 and a lower limit of 0.931g/cm2. Over this time, 67 data points were plotted, and their mean BMD value calculated, this measured at 0.946g/cm2 along with a standard deviation value of 0.002g/cm2 and coefficient of variation of 0.233%. The results for all QC are kept in a file within the Scan room. Medical Physics carry out a QA routinely every 2 years or more frequently following major repair.

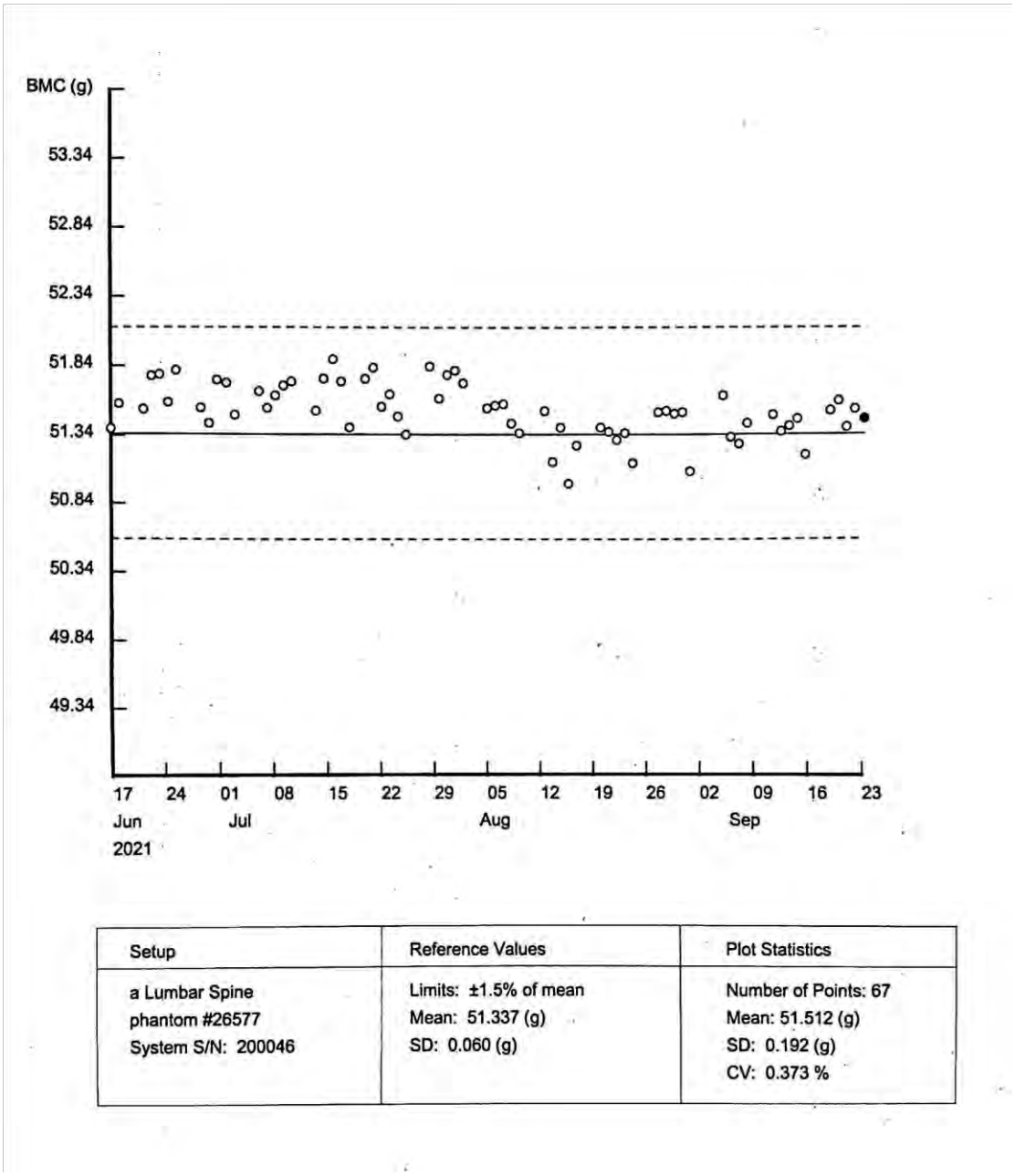

Figure 3: A daily phantom QC graph plotted for BMD between 17th June 2021 to 17th September 2021. As you can see there was a step drop in the QC results around August. This drop can be due to multiple reasons, including phantom positioning and error by the technician, high or low temperature of the room or connectivity issues. Room temperature check, visual inspection of the scanner including the XRay tube along with a repeat run of the QC follows. If all fail to rectify the issue an engineer will be contacted and management notified immediately of the fault.

Over this 3-month period the data collected, and values plotted fall within the set thresholds, sitting relatively close to the reference mean which indicates that the instrument is performing correctly. If a point falls outside the set limits, then the QC scan will automatically fail. In some cases, the phantom may just need re-repositioning before the scan is repeated. If the scan fails again it could indicate a systematic error which will require further investigations carried out by a qualified engineer before the scanner may be used for clinical investigations.

The procedure I would take if the equipment obtained an error or fault would be to firstly check the error code on screen and check the details relating to the error. I would then check all connections and visually inspect the underside of the scan bed for and leaks from the X-ray tube. If no leaks were visible, I would restart the scanner to see if that rectified the issue. As room temperature can affect the equipment, measuring the temperature of the room may diagnose the issue.

If the QC had ran and the plot was out of specification I would firstly re-position the phantom and re-run the QC to double check that it has been positioned correctly. If the equipment continued to show an error or if the QC continued to drift. I would inform a senior staff member and contact an engineer at VERTEC to diagnose the problem at hand.

7. Quality management systems

All our work practices are carried out according to protocols and include the following;

- Accepting referrals only if they meet the referral criteria
- A process in place for Practitioners to approve the referral
- Operator to confirm referral authorised
- Checking patient ID prior to scanning
- Checking pregnancy status.

- Limiting patient dose
- Recording details of individuals acting in role of comforter and carer
- All scans carried out according to schedule and individual clinical pathways • Data recorded appropriately
- Staff all trained and aware of individual responsibilities and accountabilities

Quality management schedule also includes QC procedures. All equipment undergoes critical inspection and acceptance testing at installation and after any major repair. There is a routine QC programme in place including routine QA of equipment by the [redacted] medical physics team to check safety features, radiation output, radiation scatter or radiation leakage.

Risk assessments, Local Rules, policies and procedures all reviewed and updated regularly and changes fed back to the team by the chief technician. Radiation updates produced for the team when required and at least annually. Within our department we have a clinical QA system in place and peer audit. There is ongoing quality assurance of scan analysis and clinical decisions made/ imaging requested and review of the reading of VFAs and Xrays. This is carried out by medical staff reporting the scans and queries are returned to us to action. The medical staff carry out reporting audits and peer review of reporting to check for accuracy and to highlight any inconsistencies of approach. We also run monthly X-ray meetings to discuss clinical cases with the radiologists There is also a protocol for all clinical activity. All protocols are filed within the shared departments drive for access at any time.

7.1 Clinical Audit of Bone Densitometry

Quality Assurance

Within the [redacted] our DXA service has a quality assurance programme that ensure standards are being met and are part of the local compliance assurance framework. They include, peer reviews, double reporting, audit cycle, feedback from users, reference to local treatment algorithms and agreed text for recently used recommendations. Clinical Audits are important in improving the standards of clinical practice and within the [redacted] we undertake audits in bone densitometry as discussed below.

QA of Densitometry Technique

Quality assurance of densitometry assessment is performed every 3 months by as many DXA technicians as availability allows. Each scan technician has 5 scans, selected at random from the previous months scanning and reviews their own scans and the scans of other technicians in rotation and assessed with reference to standard operating procedures for both acquisition and analysis of scans. These scans are then reviewed by the Chief Technician or Senior Scan technician to then ensure consistency. The scans must also be checked to ensure the biographic data is correct, including date of birth, sex, appropriate ethnic reference range and the patients current height and weight.

Hip Scan

Scan acquisition

The entire proximal femur should be in the field of view (FOV) and should have sufficient space on the superior and medial aspect of the femoral head. This allows for an extension of the Region of interest (ROI) in situations where there is inadequate bone edge detection. The femoral shaft should be vertical in the FOV. Baseline scan position should match unless the baseline is incorrect. Correct abduction of hip as assessed by little or no lesser trochanter visible on the image or a comment to why

the positioning is suboptimal (eg: difficulty positioning patient). External artefacts that are removable should not be present within the region of interest. Metal studs are acceptable if overlying the femoral head and are not within the neck box.

Scan analysis

There should be correct positioning of the ROI. 5 Pixels from the greater trochanter, 10 pixels from the lower margin or lesser trochanter and at least 5 pixels from the medial or posterior aspect of the femoral head. There should be correct bone map, positioning of the midline and neck box and again if any artefacts are present or positioning was difficult this should be noted. If femoral neck and Total hip BMD show a large discrepancy again reason should be noted to why this is.

Follow up scans

Same scan mode should be used with follow up scans and the ROI should match the baseline scan. Similar abduction and rotation of hip or if incorrect previously this should be corrected. Sub regions should be placed correctly.

Spine Scan

Spine Scan acquisition

The spine image should be straight and centred within the ROI with no removable external artefacts present within the region of interest unless patient cannot remove them such as navel piercings, which should be documented if that is the case. Correct landmarks should be identified (L5, T12).

Spine Scan analysis

The correct ROI should be identified along with the correct bone map. Segmentation and identification of individual vertebra levels should be correct. Segmentation that may be unclear should be documented on the assessment sheet. Image interpretation should include the appropriate exclusion

or inclusion of vertebrae. Identification of artefacts internal or external and comments made about any abnormalities within the spine.

Follow up scans

The same scan mode should be used for follow up scans, ROI and segmentation should match the baseline scans unless either a change in the anatomy or positioning warrants a different global ROI length or if the baseline was incorrect. If the baseline is incorrect is should be reanalysed unless a reason for it being incorrect is known. All knew abnormalities should be excluded.

Forearm Scan

Scan acquisition

The image of the forearm should be straight and centres within the FOV. Must be positioned best possible to allow correct placement of the global ROI.

Scan analysis

The ROI must be correctly identified with the correct bone map and sub-regions. There should be no external artefacts present within the ROI. Any comments regarding artefacts or positioning issues should be noted by the technician.

All finding are recorded and reported back to each individual technician by the chief or senior technician.

Referral Justification

All referrals should be both justified and authorised under a written protocol by approved and appropriately trained staff. The same scans that were randomly selected for the densitometry technique QA are also used for the referral audit. Referral forms must be signed on the form or electronically by the referring clinical or approved by non-medical referrers. The clinician indication